The Cronin effect in d+Au collisions at $\sqrt{s_{NN}} = 200$ GeV

Lijuan Ruan
Nuclear Science Division, Lawrence Berkeley National Laboratory, Berkeley, California 94720

The hadron p_T spectra have been observed to depend on the target atomic weight (A) and the produced particle species in lower energy p+A collisions. This is known as the "Cronin Effect", a generic term for the experimentally observed broadening of the transverse momentum distributions at intermediate p_T in p+A collisions as compared to those in p+p collisions. The effect can be characterized as a dependence of the yield on the target atomic weight as A^α. At energies of $\sqrt{s} \simeq 30$ GeV, α depends on p_T and is greater than unity at high p_T, indicating an enhancement of the production cross section. The effect has been interpreted as partonic scatterings at the initial impact [1, 2]. Thus, the Cronin effect is predicted to be larger in central d+Au collisions than in d+Au peripheral collisions [3]. At higher energies, multiple parton collisions are possible even in p+p collisions [4]. This combined with the hardening of the spectra with increasing beam energy would reduce the Cronin effect [2]. At sufficiently high beam energy, gluon saturation is expected to result in a relative suppression of hadron yield at high p_T in both p+A and A+A collisions and in a substantial decrease and finally in the disappearance of the Cronin effect [5].

Nuclear effects on hadron production in d+Au collisions are measured through comparison to the p+p spectrum, scaled by the number of underlying nucleon-nucleon inelastic collisons using the ratio $R_{dAu} = \frac{d^2N/(2\pi p_T dp_T dy)}{T_{dAu} d^2\sigma_{inel}^{pp}/(2\pi p_T dp_T dy)}$, where $T_{dAu} = \langle N_{bin}\rangle/\sigma_{inel}^{pp}$ describes the nuclear geometry, and $d^2\sigma_{inel}^{pp}/(2\pi p_T dp_T dy)$ for p+p inelastic collisions is derived from the measured p+p NSD cross section. The difference between NSD and inelastic differential cross sections at mid-rapidity, as estimated from PYTHIA, is 5% at low p_T and negligible at $p_T > 1.0$ GeV/c. Fig. 1 shows R_{dAu} of $\pi^+ + \pi^-$, $K^+ + K^-$ and $p + \bar{p}$ for minimum-bias and central d+Au collisions measured from the Solenoidal Tracker at RHIC. The systematic uncertainties on R_{dAu} are of the order of 16%, dominated by the uncertainty in normalization. The R_{dAu} of the same particle species are similar between minimum-bias and top 20% d+Au collisions. In both cases, the R_{dAu} of protons rise faster than R_{dAu} of pions and kaons. The R_{dAu} of the identified particles has characterstics of the Cronin effect in particle production with R_{dAu} less than unity at low p_T and above unity at $p_T \gtrsim 1.0$ GeV/c. This behavior is contradictory to the prediction from gluon saturation model, indicating that hadron suppression at intermediate p_T in Au+Au collisions is due to final-state effects. We can also study Cronin effect of the identified particles by comparing the α parameters of protons and pions. At lower energy, the α parameter in the power law dependence on target

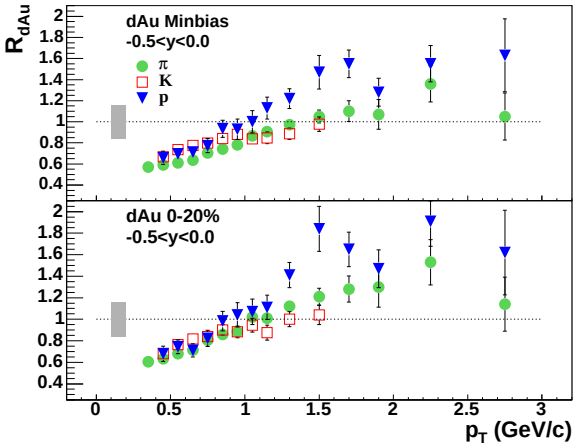

FIG. 1: The identified particle R_{dAu} for minimum-bias and top 20% d+Au collisions. The filled triangles are for $p + \bar{p}$, the filled circles are for $\pi^+ + \pi^-$ and the open squares are for $K^+ + K^-$. Errors are statistical. The gray band represents the normalization uncertainty of 16%.

atomic weight A^α of identified particle production falls with $\sqrt{s}$ at high p_T ($p_T \simeq 4.6$ GeV/c). From the ratios of R_{dAu} between $p + \bar{p}$ and $\pi^+ + \pi^-$, we may further derive the $\alpha_{p+\bar{p}} - \alpha_{\pi^+ + \pi^-}$ for $1.2 < p_T < 3.0$ GeV/c to be 0.048 ± 0.012(stat)± 0.006(syst). This result is significantly smaller than the value 0.081 ± 0.005 in the same p_T range found at lower energies. In summary, we have reported the Cronin effect of pions, kaons, and protons at mid-rapidity from 200 GeV p+p and d+Au collisions. The particle-species dependence of the Cronin effect is found to be significantly smaller than that from lower energy p+A collisions.

[1] M. Lev and B. Petersson, Z. Phys. C **21**, 155(1983).
[2] A. Accardi, Contribution to the CERN Yellow report on Hard Probes in Heavy Ion Collisions at the LHC, hep-ph/0212148; X.N. Wang, Phys. Rev. C **61**, 064910 (2000).
[3] I. Vitev, Phys. Lett. B **562**, 36 (2003).
[4] T. Alexopoulos *et al.*, Phys. Lett. B **435**, 453 (1998).
[5] D. Kharzeev *et al.*, Phys. Lett. B **561**, 93 (2003); J. Jalilian-Marian *et al.*, Phys. Lett. B **577**, 54 (2003); J.L. Albacete *et al.*, Phys. Rev. Lett. **92**, 082001 (2004); D. Kharzeev *et al.*, Phys. Rev. D **68**, 094013 (2003); R. Baier *et al.*, Phys. Rev. D **68**, 054009 (2003).